The ATR – a French/Italian manufactured turboprop – is most commonly used by regional operators due to its climb performance and relative fuel efficiency. An overview of its maintenance planning document (MPD) and line & base airframe maintenance requirements are examined.

ATR 42/72 airframe maintenance

The ATR turboprop family entered service in 1985, with the ATR 42-300. This early model was powered by Pratt and Whitney PW120 engines, derivations of which are used on the rest of the 42 and 72 families. Hamilton Standard propellers are used on all ATR variants, originally starting with four-bladed, 14SF-5 propellers on the -300 series.

This article will explore the airframe maintenance requirements for the ATR's line and base maintenance cycles. These requirements start with the ATR's maintenance planning document (MPD), which provides a basic overview of the ATR's core maintenance requirements. This takes into account tasks based on flight hour (FH), flight cycle (FC), calendar driven tasks, and others. Where applicable, it will be determined how much labour the routine checks and groups of tasks use alongside the general factors that maintenance providers attribute to each task type to allow for non-routine (N-R) findings.

Seat capacity is 42-48 seats on the ATR 42 family, and up to 78 seats across the ATR 72.

The ATR 72 is a stretch of the ATR 42, and was launched in January 1986 as the -200 series. The fuselage is 4.5 metres longer and the wingspan is wider. This provides increased seat capacity to match regional airline demand.

The ATR 72-200 was the first variant of the stretched ATR 42, powered by PW124B engines, and Hamilton standard 14SF-11 four-bladed propellers. Initial passenger capacity was 66 seats.

Successive series of the ATR 72 have been introduced, resulting in an aircraft that can seat up to 78 passengers in a single-class configuration, including: the ATR 72-210, which has PW127 engines and four-bladed HS 247F-1 propellers; and the ATR 72-500, which has PW127F and/or M variants and six-bladed HS 568F propellers. The PW127M also powers the ATR 72-600, which has the same propellers as the -500.

Passenger-to freighter conversions for the ATR include a large cargo-door conversion, bulk-freighter conversion, ATR corporate, and ATR surveyor variants. Passenger-configured ATRs are the most numerous in operation.

The variants still in production include the ATR 42-500 and -600, and the ATR 72-500 and -600 derivatives. The total global fleet of ATRs in operation, including cargo and passenger variants, exceeds 800. Of these, 560 are ATR 42 and 72 -500 and -600 variants which will be the main focus of this analysis.

Engine upgrades to improve efficiency and performance are possible between the PW127F and M models, and cost operators $300,000 plus a shop visit fee.

The ATR's versatility has made it an aircraft of choice for freight companies, regional airlines, and low utilisation operations such as island hoppers. It is primarily owned by European and US operators and leasing companies. Nordic Aviation capital is a key lessor for the ATR, with a fleet of more than 100 ATR 42s and 72s. Key operators include HOP!, which operates 23 ATR 42 & 72 -500s/-600s.

Maintenance considerations

The ATR 42 and 72 have similar performance and maintenance task demands, because they have the same fuselage cross-section and the same flightdeck to allow cross-crew qualification. The ATR 72 has 10% more maintenance planning document (MPD) tasks than the ATR 42. These are mainly structural and system tasks related to ATR 72's engines, and its additional fire extinguishers and oxygen bottles.

Based on averages for those operating the -500 and -600 variants in a passenger configuration, an annual utilisation of 1,760FH and 1,900FC has been assumed. This equates to 150FH per month, and an average flight time of 55 minutes for every sector flown. This is equal to a FH:FC ratio of 0.92:1.0.

The maintenance requirements for an average passenger-configured aircraft, operated by a regional airline, will be explored. This demonstrates the mainstream use for the ATR, and will embody the key focus of the reasoning behind the MPD's general structure.

It stands to reason, however, that an MPD will need to be adaptive to apply to airlines operating a higher or lower FH:FC ratio. As some MPD tasks are specified with FH or FC intervals, the airline's operating ratio will affect the grouping of MPD tasks into maintenance checks. The FH:FC ratio may therefore increase or delay the frequency of heavy tasks and checks for some operators.

Typically, for instance, the ratio for a cargo or freight operator will be a longer average flight time than a regional airline. All operators have one thing in common: the need to keep an aircraft in the air and active for as long as possible, by limiting downtime spent in a maintenance hangar to perform maintenance tasks and checks. This must, obviously, not be to the detriment of safety or overall reliability.

The ATR 42's and 72's maintenance requirements and check arrangements have been analysed *(see ATR 42/72 maintenance cost analysis, Aircraft Commerce, December 2006/January, page 12)*. Many MPD revisions, ADs and SBs have been issued since 2007.

A key example is the extension of the C check, now referred to as the 'base check', interval from 4,000FH to 5,000FH. A base check is a substantial

There are more than 800 ATRs in airline service. Typical rates of annual utilisation are about 1,800FH and 1,900FC.

maintenance package that typically involves structural and deep access items.

Analysis of the MPD has allowed further insight into how operators can group out-of-phase (OOP) tasks with larger groups of tasks to form manageable check packages. These can be referred to as 'A' checks, and base checks. Doing this can increase operational efficiency, and minimise downtime for maintenance.

Common considerations

There is little or no difference between MPD tasks that apply to the ATR 42 and 72 types. Each main type has a separate MPD, and there are about 1,100 tasks in each MPD.

Mainly because of the ATR 72's larger fuselage over the ATR 42, more labour man-hours (MH) are required for the ATR 72. The main additions to the ATR 72's MPD are maintenance tasks relating to galley removal, safety equipment inspections and structural inspections of its extended fuselage. This is because certain inspection tasks will take longer to perform.

When analysing the MPD for each type, other factors have to be considered in addition to the tasks, their intervals and stated inspection MH. There is an effectivity column, which refers to the series and variant, aircraft line number (L/N), as well as the aircraft's technical and modification status. This means there are some tasks which are not relevant to the entire fleet.

About 530 tasks are categorised as 'effectivity all', meaning they are applicable for the entire fleet and all L/Ns. About 10 tasks relate to the type of HS propeller installed. A handful depend on the manufacturer serial number (MSN) or L/N of the aircraft. An example is the inspection to detect cracks on the lower front spar via a visual inspection.

Most of the effectivity tasks, however, have to be considered in relation to the aircraft's modification status. This may be due to airworthiness directives (ADs) that have been issued during the ATR's production life. About 524 tasks are influenced by aircraft modification and AD status. They are denoted by a 'pre-' or 'post-', followed by the reference for the modification in the effectivity column. A task will therefore apply to an aircraft depending on whether or not it has undergone the modification.

It is via these specific parameters, therefore, that the MPD can be tailored to each aircraft according to its technical status.

Zones of the aircraft are also listed in the MPD for each task, and they relate to specific dimensions and areas that the aircraft is divided into. These zones are outlined in the introductory pages of the MPD. Zones are assigned to each task, so that the mechanic knows the relevant area for preparation and access. For instance, three-digit zone numbers that start with 5 (for example 560) refer to the LH wing; while those starting with 6 (for example 660) relate to the RH wing. Consecutive zone numbers suggest access panels situated near each other.

While MPD tasks will be common for all operators, and are established by the OEM, there will also be many requirements added by the operator. These are discretionary, and will vary from operator to operator. Additional tasks will be in the form of job cards and are supplementary, meaning that more downtime and work are added to the core labour MH. They usually relate to interior standards of the cabin and cosmetic work, but may also be specific to the operator's style of operation and route network.

MPD tasks must be considered the bare minimum by operators to adhere to and promote airworthiness.

Types of MPD task

The 1,100 or so tasks in the core MPD include those driven by FH, FC, and calendar intervals. Tasks with dual FC and calendar intervals are performed according to whichever is reached first.

Many of the FH tasks are generally system-related inspections, while many of the calendar tasks are structural inspections. FC tasks are typically fatigue and structural inspections.

Some tasks with calendar limits have a relatively high initial threshold and are followed by a shorter repeat interval.

Many tasks share the same intervals and so form large groups that form the basis of the main A and Base checks.

There are also OOP tasks, which are smaller numbers of tasks with intervals that fall between the main groups of tasks.

There are also other wider tasks, including those driven by national requirement (NR) or vendor requirement (VR), and those related to engine or propeller removal. These tasks may direct the mechanic or technician to the maintenance manual relating to these items to carry out the relevant inspection.

All of the above tasks, with preset inspection intervals, are typically referred to as 'routine' tasks.

An additional but unpredictable element of maintenance to an operator is when 'non-routine' tasks or defects occur. These can be flagged while the aircraft is in operation, and therefore cannot be predicted, or arise from the routine inspection tasks. Due to the fact that non-routine snags are an almost inevitable occurrence in A and Base checks, maintenance planners try to factor in a portion of anticipated non-routine tasks in airframe checks when estimating MH requirements.

The ratio applied to probable MH for routine tasks is referred to as the 'defect ratio'. Although this is not included in the MPD, this enables maintenance providers to give customers a realistic estimate of

ATR 42 & 72 MPD TASKS SUMMARY

Interval criteria	Tasks description	Interval range	Number of tasks
A check tasks	1A, 2A & 4A	500FH, 1,000FH & 2,000FH	77
C check tasks	1C, 2C & 4C	5,000FH, 10,000FH & 20,000FH	320
FH	Out-of-phase (OOP)	400-9,600FH	85
FC	Mainly ageing	600-3,000FC plus 18,000-36,000FC	223
Calendar	Structural & deep access tasks	1 week & 6MO, 1YE/2YE/4YE/8E/12YE	308
Dual interval			45
VR & NR			24
Total tasks			**1,082**

the check's downtime and its total MH input.

It is expected that, as an aircraft ages, this defect or N-R ratio will increase. The rate at which this ratio rises will be affected by the aircraft's stage in its base check cycle. It can be assumed that a new aircraft will have a low defect ratio applied in the early stages of its base check cycle. The ratio will increase as the aircraft progresses through its third and fourth checks in the first base check cycle. This is due to the gradual rise of operational wear and tear.

There is also the issue of corrosion. It has a high occurrence in the deep access and fatigue tasks, many of which came due in the first base check cycle and during the second base check cycle.

A large number of N-R items and defects are cleared during the last and heaviest check of the base check cycle. The N-R ratio of the subsequent and first check of the second base check cycle should therefore be lower. The ratio will then rise again with each check during the second base check, and will be highest at the last check of the second cycle. It will be higher than at the end of the first base check cycle.

Latecoere Aeroservice is located in Toulouse and Montpellier. It offers maintenance, repair and overhaul capabilities for all ATR types, including line, base and heavy maintenance. It also specialises in lease returns for ATR aircraft, which includes offering aircraft painting, and storage and modifications to aircraft entering new lease agreements. "In our experience we typically see that one routine MH generates up to two MH of non-routine work on the ATR," says Jean-Christoph Rollier, technical officer at Latecoere Aeroservice.

Preparation & access

Different tasks require varying levels of access. A simple task, such as a visual or functional check, will often not require access via a panel or the removal of interior items, so preparation will involve little additional labour time. Similarly, a systems check such as an avionics test is often also non-invasive. Deep access tasks, that account for a high portion of tasks in structural checks, require more planning, preparation and labour time to gain access to the area or zone of the aircraft that needs inspection.

"The MPD has an allowance to inspect the section of panels specific to the task; the 'inspection MH'," explains Rollier. "The MPD often takes into account the labour to access the area, known as the 'access MH'. The access time is different to the 'preparation' time, however. Preparation MH are not always included in the ATR MPD for certain tasks. An example is carpet removal and replacement."

The preparation time may account for a substantial part of the overall tasks in a check. In the scenario, for example, of the galley floor inspection that requires deep access, the preparation would include the removal and subsequent replacement of the galley and all cabin seats, which may take an additional 40-60MH, depending on the size of the cabin and number of galleys.

While the ATR MPD allots an overall MH estimate to carry out the inspection for each task, therefore, the MH estimate does not generally indicate the actual time used to carry out the inspection. By factoring in additional MH or a multiple of MPD MH, maintenance planners can create a more realistic idea of the downtime and MH required for routine inspections and to perform a check. This factor will vary with the age of the aircraft, and its stage in its maintenance cycle. The industry average multiplication factor for an aircraft in the first 15 years of operation may be about 2.5, whereas as it gets older and approaches fatigue and age-related inspections, this factor may increase to 3.5.

Maintenance programme

"ATR maintenance is based on MSG3 philosophy," confirms Philippe Delisle, chief executive of the Sabena Technics Dinard facility. "It has two dedicated MPDs: one for normal operation, and one for low utilisation for aircraft operating less than 1,000FH per year."

This analysis refers to an MPD for the ATR 72, Revision 22, issued October 2015. There are about 1,100 tasks described in the document *(see table, this page)*. The ATR 42's and 72's maintenance requirements are analysed for normal airline operation.

First, there are the main task groups that relate to scheduled line and base checks on the ATR 42 and 72 families.

These include three main groups of 77 A check tasks, and three main groups of 320 Base check tasks *(see table, this page)*. These all have FH intervals.

In addition, there are 85 OOP tasks that are determined by an FH interval, 223 tasks with an FC interval, and 308 calendar tasks that range from weekly, monthly or year (YE) task groups *(see table, this page)*. There are also 45 tasks with dual intervals. There are six different interval criteria combinations. Most have relatively short intervals.

Last, there are 24 VR and NR tasks. In addition, some inspections fall under a 'note' category that mostly relates to propeller and engine removal tasks. It is therefore a requirement to consult OEM manuals for these items.

The 85 OOP tasks have intervals between 400FH and 9,600FH, and will be grouped into A and base checks as deemed appropriate.

A substantial part of the MPD refers to ageing maintenance on the aircraft, with about 214 of the 223 FC tasks that have initial and repeat intervals. The initial intervals are between 18,000FC and 36,000FC. The other nine FC tasks have intervals between 600FC and 3,000FC.

Of the 214 ageing tasks, 209 are sampling tasks. These 209 only affect 20% of the aircraft in an operator's fleet, so they do not necessarily apply to every ATR 42/72 in service. This will be expanded on later. There are therefore five ageing tasks that apply to all aircraft.

The 214 ageing tasks have a range of initial intervals. There are three tasks

A CHECK TASKS GROUPS & ROUTINE MH REQUIREMENT

A check	FH interval	Main A check task groups	Routine MH
A1	500	1A	20-39
A2	1,000	1A+2A	25-51
A3	1,500	1A+3A	325-63
A4	2,000	1A+2A+4A	50-99
A5	2,500	1A	22-45
A6	3,000	1A+2A+3A	33-66
A7	3,500	1A	20-39
A8	4,000	1A+2A+4A	126-153

with an initial interval of 18,000FC, one with an initial interval of 21,000FC, 24 with an initial interval of 24,000FC, two with an initial interval of 27,000FC, and 184 tasks with an initial interval of 36,000FC.

Of the 308 calendar tasks, 290 have intervals between 1YE and 12YE. Many of these involve structural and deep access inspections.

The lightest maintenance is the recurring line maintenance-based tasks involving a 24FH visual check of the engine oil level. A weekly group of 17 tasks is also required. The main elements typically involve functional checks of the brake assembly and discs, a general visual inspection of the main wheels, and walkaround inspections of the fuselage and landing gears.

There is a cycle of four A checks; the A1, A2, A3 and A4 checks. The basic A check interval is 500FH, and so the A4 check and A check cycle has an interval of 2,000FH *(see table, this page)*. The three main groups of routine A check tasks have intervals that are multiples of 500FH.

There is a cycle of four base checks in the check cycle. These can be referred to as the Base 1, Base 2, Base 3 and Base 4 checks. The Base 4 check has the largest number of tasks, and so is the heaviest check in the cycle.

The base check has an interval of 5,000FH, so the Base 4 check and Base check cycle has an MPD interval. The three main groups of routine C check tasks in the MPD have intervals that are multiples of 5,000FH. These C check tasks account for the bulk of base checks, previously known as C checks.

The second and third base check cycles are repeats of the Base 1 to Base 4 checks.

"In addition to the groups of C check tasks, there are also four main groups of calendar tasks. These are at 2-, 4-, 8- and 12-year intervals. That is, 2YE, 4YE, 8YE and 12YE tasks. Operators often include these in the base checks. There are also the ageing tasks, most of which have initial intervals of 36,000FC," continues Delisle. These will therefore come due for the first time after 21 years of operation.

"For normal operation, A checks have a ground time of 24-48 hours every 500FH, while base checks are required every 5,000FH and have a ground time of one to two weeks, depending on the contents of the check," says Delisle. Heavier base checks can last up to three or four weeks.

An aircraft typically undergoes three separate maintenance phases during its life. The initial period is known as the 'First-Run' interval. As the name suggests, this occurs over the initial operating years, generally considered the first four to six years of in-service operation. Since all systems on the aircraft are relatively new over this period, there is a low incidence of non-routine maintenance and material scrap rate.

The mature-run or phase begins after the first phase, and the first base maintenance cycle is completed during the early part of the mature phase. Some of the heavier calendar tasks come due within this period, and defects might start to be raised more frequently as the aircraft begins to show 'wear and tear'. Cosmetic requirements, such as interior refurbishment, may also come into effect over this period. Interior refurbishment typically falls between the first heavy maintenance visit and the second maintenance visit. That is, during the second base check cycle.

Last, the ageing phase begins when the effects of airframe age result in higher non-routine costs. This period typically begins after the second heavy maintenance visit and during the third base or base check cycle, and continues to increase with age. The ageing phase often includes the substantial fatigue tasks, or 'ageing tasks' that commence at about 36,000FC, as described.

Out-of-phase tasks

In general, OOP tasks are relatively minor tasks, including system checks. OOP tasks in the ATR 72's MPD include light inspections, such as the removal and check of the main battery, a functional check of the starter generator brushes, a detailed visual inspection of seats on the flightdeck and smoke detection checks.

Rheinland Air Services (RAS) is headquartered in Monchengladbach and offers full MRO services for the ATR family. It is also a global maintenance agreement (GMA) service partner for ATR, allowing RAS to offer full maintenance management services for its customers. "These OOP tasks will often be brought forward and combined to meet with a weekly check, A check or maybe a base check, depending on when each task group falls," explains Joerg Peters, director of maintenance at RAS.

OOP tasks are often light in required effort for the maintenance provider, but they can be time consuming and force additional downtime if they are not combined and grouped with the main airframe checks. If OOP tasks require a large number of MH, it will often by integrated into a base check by operators. An example of this is an engine change, which can take about 120MH to perform.

A check tasks

A checks are scheduled every 500FH. These only require minimal and light access and preparation time. These mainly include system tasks, and are checks which have a downtime of about two days to complete. This includes rectifications and supplemental tasks due at the time.

The three A check task groups have intervals that are multiples of 500FH. These are the 1A at 500FH, 2A at 1,000FH and 4A at 2,000FH. The A1 check thus has just the 1A tasks, the A2 check has the 1A and 2A tasks, the A3 check has just the 1A tasks, and the A4 check has the 1A, 2A and 4A tasks *(see table, this page)*.

The first group of A check tasks listed in the MPD is the 1A tasks. There are 33 tasks that require about 8MH for the actual inspection, according to the MPD. These have an interval of 500FH, and so are included in every A check.

Applying the MH planning factor of 2.5 brings a realistic labour requirement

The ATR's base airframe check cycle is structured around groups of C check tasks which have multiples of 5,000FH.

of more than 21MH for the 1A tasks alone. Much like the OOP tasks, mainly operational tests and visual checks are required for the 1A tasks. These include an inspection of the passenger door's folding step, visual check of the flight and forward avionics compartment, and inspection of the cabin including windows for damage. There are different inspection tasks depending on whether the cabin is cargo- or passenger-configured.

The 2A tasks listed in the MPD, with an interval of 1,000FH, comprise about 12 inspections, with inspection times requiring 4MH. After factoring, this equates to just over 10MH for routine inspections, although little allowance is given for access or preparation time in the MPD.

Inspections included in the 2A tasks are the cleaning of draining holes and filters on door thresholds to remove obstruction, operational testing of the DC bus power control unit (BCPU), a check of the rudder damper for fluid level and leakage, and checks of the main and nose landing gear shock absorbers.

The MPD also has tasks listed with an interval of 1,000FH, which may be viewed as OOP tasks. These include the inspection of igniter plugs for condition. These can also be grouped with the 2A tasks.

The 2A tasks are generally performed every second A check, or at 1,000FH intervals. They will therefore be included in the A2 and A4 check of the A check cycle.

The 3A tasks have an interval of 1,500FH, and can be first included with the A3 check and then every third A check thereafter. These will therefore be the A3, A6 and A9 checks; and every third A check thereafter.

There are only two 3A tasks, although they involve detailed borescope inspections of the low pressure (LP) impeller in the engine, and the 6th and 7th housing vent transfer tubes for build-up of carbon.

There are 30 4A tasks with an interval of 2,000FH. They mainly involve lubrication of door bolts, hinges and actuator bearings. An inspection of the air cooling is also carried out, and valve inspections. A general inspection is made of the engine and oil cooler air intake fairing, and the nacelle rear section and exhaust for leaks and general connections. It can be expected that the 4A tasks use 60-80MH. 25MH of this is commonly used to access the areas.

Assuming the established average annual utilisation of 1,800-2,000FH, it would follow that about four A checks, and so a cycle of A1, A2, A3 and A4 checks, occurs during a calendar year. This would be equal to an A check every three or four months.

Generally, a basic A check package for routine tasks can be set at about Eur 5,000. This basic price is purely for the routine inspections and does not include additional OOP tasks, or non-routine findings and rectifications. It also does not factor in component checks, which will vary from operator to operator. Once N-R findings have been raised, and materials and OOP tasks have been included, the cost of an A check can vary from Eur 15,000 to Eur 40,000.

"It often makes sense to do hard-time component changes during the A check," summarises Peters. "There is usually enough downtime and opportunity to accomplish this. These components typically include LLPs, landing gear, starter generator, propeller parts and engine changes. Small ADs and SBs will often also incorporated into an A check."

Other work can be combined with the A check to reduce aircraft downtime. "Cleaning works are mainly done during these checks, alongside the component changes," confirms Delisle at Sabena Technics.

The total MH for routine tasks in the A checks are summarised *(see table, page 48)*. These vary from 20-39MH for A1 checks with just 1A tasks, up to 50-100MH for A4 checks with 1A, 2A and 4A.

In addition to these routine tasks there will be non-routine rectifications and defects. These will be partly due to findings as a result of the routine inspections and tasks, but the rectification of operational defects that have been deferred by the line maintenance department. The A check presents an opportunity to clear these.

A deep clean and rectification of cabin items will also be included in an A check package.

The total labour requirement for light A checks will therefore reach or exceed 100MH. Heavier A checks usually exceed 150MH.

Base check tasks

Base check tasks are set in the MPD at multiples of a 5,000FH interval. This was escalated from 4,000FH in 2007.

For the ATR, base check task groups are presented in the MPD as 1C (every 5,000FH), 2C (every 10,000FH) and 4C (every 20,000FH).

The average downtime to complete a lighter base check is one to two weeks, depending on the task groups included. Given the average utilisation of ATR operators, the base checks commonly occur every two to three years. "Base checks mostly include operational, functional and system tasks throughout the airframe, together with general wear and tear," says Peters.

A basic base check package can start at about Eur 40,000 for the routine C check tasks. Adding N-R findings and extra OOP tasks can increase this to nearer Eur 500,000 for operators in terms of time and material on the airframe.

ATR 42 & 72 BASE CHECK TASK GROUPS

Base check	Probable FH interval	Calendar interval	Main C check & other task groups	Routine MH
Base 1	3,800	24 months	1C + 1YE + 2YE	505-570
Base 2	7,600	48 months	1C + 2C + 1YE + 2YE +4YE	985-1,100
Base 3	11,400	72 months	1C + 2C + 1YE + 2YE + 4YE + 8YE	1,285-1,450
Base 4	15,200	96 months	1C + 2C + 4C + 1YE + 2YE + 4YE + 12YE	1,500-1,620

"Base checks include the main routine MPD C check tasks, OOP tasks, ADs and SBs, and non-routine rectifications and deferred defects," says Delisle. "General refurbishment will also occur during a base check. Landing gear and engine inspections and tasks are also normally scheduled during a base check."

The only C check task group in the Base 1 check is the 1C tasks at 5,000FH. The Base 2 check at 10,000FH has the 1C and 2C tasks; while the Base 3 check at 15,000FH also has just the 1C tasks. The largest Base 4 check at an MPD interval 20,000FH has the 1C, 2C and 4C tasks *(see table, this page)*.

As noted by the name, these heavy checks take place in the maintenance hangar or 'base'.

There are 188 1C tasks in the MPD. Access and preparation time is often not accounted for. Neither are non-routine tasks arising from defects. It is estimated that the average 1C tasks take 230MH to complete for the ATR42-500/-600 and 250MH for the ATR 72-500/-600.

The 2C group has 84 basic tasks, but the inspections are heavier and require more access than the 1C tasks. Before being combined with the 1C tasks, the 2C tasks again take a factored time of about 230MH, including access and preparation time, for the ATR 42-500/-600, and 250MH for the ATR 72-500/-600.

The key tasks in this group include operational tests of the air cooling system, the manual pressure control system, and the oxygen distribution system. Visual inspections take place in the rear cone area, elevators, rudders and ailerons, among others. There are also some cleaning and lubrication tasks.

There are 48 core 4C tasks. These will be combined with the 1C and 2C tasks to form the Base 4 check. Downtime for this heavy check is identical for the ATR 42 and ATR 72. Typically, the 4C tasks will take about 200MH of preparation, access and inspection time.

The 4C tasks include more visual inspections and functional tests. These include an inspection of the wings' outboard leading edges, engine fire protection bays, and cabin ceiling. The functional tests relate to the fuel level system fuse adaptors, and take about 1MH to inspect.

As will be explored later on, once combined with the calendar tasks that fall in with average utilisation, the contents of a typical base check will become more substantial than just the sum of its groups of 1C, 2C and 4C tasks. This will extend the downtime of the aircraft for a single base maintenance event, rather than performing separate checks.

Deep access tasks

Tasks that require deep access, such as the removal of floor panels and major structures, are mainly the 2YE, 4YE, 8YE and 12YE tasks *(see table, page 46)*.

In accordance with the MPD, this group of tasks typically comprises inspections that cover environmental corrosion damage. "These are structural checks that require substantial MH to prepare and access," explains Peters. "Subsequently, these often result in the most expensive shop visits." Preparation time and MH have to be factored in separately by maintenance shops because it is not accounted for in the MPDs.

There is also an annual group of 1YE tasks that are relatively light; totalling 11 tasks and taking about 25MH on the ATR 42 and closer to 40MH on the ATR 72.

Deep access tasks in this group includes testing the aileron mechanical control. Their interval means that they will be combined with the 2YE, 4YE, 8YE and 12YE tasks each time they come due.

These inspections are substantial. "The 2YE tasks, once combined with the annual check, can take about 120 task MH and almost the same amount of labour to access, including the removal and replacement of panels," explains Delisle at Sabena.

"The 2YE tasks can therefore often take up to 400MH, including access time and preparation for inspection," elaborates Rollier at Latecoere. This is due to the need to remove seats, carpets and underfloor panels, including the deep cleaning of associated areas.

2YE tasks include a detailed visual inspection of all passenger oxygen masks, the VHF radio antennae, and the entire lower fuselage of the aircraft. Inspection for corrosion on seat tracks throughout the cabin is also required. There is also a corrosion inspection at an access door cutout. Leak checks are also required for the air data system pneumatic lines, and pitot tube drain holes are cleaned.

The 4YE tasks require 250-280MH for the ATR 42 and 72, while the 8YE tasks require 300-350MH for the ATR 32 and 72.

Combining task groups

A base check would come due up to once every 5,000FH, and so every 30-32 months, when operating at an average annual utilisation of about 1,800-1,900FH for regional operators. It therefore often makes sense to bring forward C check tasks to coincide with the main calendar task groups that come due in multiples of two years. The calendar tasks thus come due about once every two years in multiples of 3,600-3,800FH, and therefore so will the cycle of four base checks *(see table, this page)*. "Operators will sometimes throw away maintenance intervals in the C check tasks by bringing them forward by more than 1,000FH to a two-year interval at 3,600-4,000FH, to align them with the deep access calendar tasks," says Peters. "That way, the aircraft can continue flying for two years without being grounded twice for separate base- and calendar-based checks in close succession."

Grouping tasks into base checks requires particular focus for structural and deep access tasks, which often require the most downtime. If NDT tasks are required, as is often the case with structural and deep access checks, it makes sense to ensure these take place when inspections in particular zones of the aircraft are already due in the base check.

Therefore, the first base check, or Base 1 check, at an interval of up to two years would incorporate 1C, 1YE and 2YE tasks *(see table, this page)*. "Factoring in for access and preparation time, this means a package of routine tasks for the Base 1 check of about 500MH for the ATR 42," says Peters.

The second base check, or Base 2 check, occurring at up to four years for the average ATR operator, would include 1C, 2C, 1YE, 2YE and 4YE check items *(see table, this page)*. The labour for routine tasks for the ATR 42 is close to 1,000MH.

Most ATR operators bring forward C check task groups with intervals that have multiples of 5,000FH and combine them with calendar tasks that have intervals that are multiples of two years. Base checks are performed about once every two years, with the heavy Base 4 check at eight years.

The third base check, or Base 3 check, which would be up to another two years later, and so at up to the sixth year of operation, would combine the 1C, 2C, 1YE, 2YE, and 4YE tasks. The 8YE tasks may also be brought forward at this check *(see table, page 50)*. This would result in a package requiring a total of 1,300MH for inspections and access for these routine tasks.

It should be noted, however, that the structure of these checks, such as the grouping of these tasks, will be highly dependent on the operator and its usage. For example, the 8YE tasks may instead take at the Base 4 four check, depending on whether these checks can bring the aircraft closer to the actual calendar requirement of 8 years. An ATR 42 or 72, whose operator has incorporated the fourth base check with the 8YE tasks, may be flying about 2,500FH annually, as opposed to the 2,000FH on which this analysis is structured.

Finally, the fourth base check or Base 4 check, would come due at about 15,200-15,500FH for an aircraft operating at 1,800-1,900FH per year; or at eight years. Operators are likely to include the 12YE structural tasks *(see table, page 50)*, by performing them one or two years earlier. While this means that the full 12YE interval is not utilised, it is often the best compromise for maintenance planners to avoid duplicating preparation, access and maintenance downtime.

Combined with the 1YE, 2YE, 4YE and 12YE tasks, alongside the 1C, 2C and 4C tasks, one can expect a total of 1,500MH for the routine tasks on the Base 4 check.

"There is a fuel tank inspection in the 12YE tasks that requires a video borescope, or a manual opening and closing of the fuel panels and a detailed visual inspection of the fuel tanks," explains Peters. Whether the borescope, or visual inspection is carried out depends on the licensing of the MRO. Because it is due at about 12 years, this inspection is most often combined with the 2YE and 4YE check items. "If the detailed inspection takes place, about 320MH are allotted for the opening and closing of fuel panels alongside the detailed visual inspection," adds Peters. If the video borescope is carried out, this will not take the same length of time to carry out the inspection. The borescope option is typically rated by providers at a fixed price ranging from Eur 10,000 to Eur 15,000. Depending on the operator's utilisation, this can therefore be combined with the Base 1 check that follows the fourth base check event.

Since these extensive tasks are combined, it stands to reason that some labour MH can be removed from the overall estimate for each base check, because some duplicate access time can be avoided. "When the 1C and 2YE task groups are combined, maintenance planners can typically remove about 50MH for combined access," highlights Delisle at Sabena. "This is also true for the third base check. For the second and fourth base checks, about 100MH can be deducted."

There are several OOP tasks between the main A and Base check task groups that are within only 200FH of each other, starting from 1,000FH, 1,200FH and continuing up to 5,000FH. "Most operators will try and incorporate these OOP tasks into 'Hangar' checks, such as the 1YE and 2YE main groups of tasks, to prevent additional downtime when the aircraft is in operation," explains Martin Gallagher, technical asset manager at Goshawk Aero.

Once an aircraft has completed its fourth base check, or Base 4 check, it has undergone its first base check cycle. If the groups of base check and calendar tasks are combined as described, the Base 4 check will be performed at up to eight years of age, and so after about 15,200-15,500FH *(see table, page 50)* and 17,200FC.

After the first base check cycle, the pattern of checks is repeated, continuing as a Base 1 to Base 4. In RAS's experience, the labour MH to complete the next base check cycle will increase, although the rate of increase depends on several different factors. "The quality of the maintenance performed in the past, plus the operational environment, will affect what is experienced in the second and third cycles," says Peters. "Highly humid climates, for example, with polluted or salty atmosphere may cause problems. The preventive maintenance carried out during the operational period between the checks will also have an effect, and this will vary from operator to operator."

The four base checks of the first base check cycle will therefore have three main task groups and a routine labour requirement of 500-570MH for the lightest Base 1 check. This will steadily rise to eight main task groups, including the large 4YE and 8YE groups of structural tasks in the Base 3, and the 4C and 4YE task groups in the Base 4 checks. These have routine MH requirements of 1,300-1,600MH.

The grouping of C check tasks will be the same in the following second base check cycle, as will the grouping of 1YE, 2YE and 4YE calendar tasks. The 8YE tasks will come due again at the Base 2 check in the second cycle, while the 12YE tasks will come due again at the Base 4 check.

Fatigue & sampling tasks

As described, there are 209 sampling tasks. These coincide with the fatigue checks at 24,000FC and 36,000FC. These do not necessarily need to be carried out across the entire fleet, however.

Calendar tasks are deep structural inspections, and most commonly check for corrosion and other environmental damage.

"The use of sampling tasks will depend on fleet size, and will be agreed with each operator's local aviation authority. Typically it is 20%. If sampling is utilised and defects found, then the task would need to be carried out across the whole fleet," explains Delisle. The interval is different for the rest of the fleet, and higher than the initial interval for the sampled aircraft.

These sampling tasks can require substantial preparation and access MH for those aircraft included in the sample 20%. The tasks mostly consist of detailed inspections, and include NDTs and borescopes. Crack detection is the most common aim of the inspections, including inspection of the aft wing pressure deck, and the torque tube inside the passenger door. Other tasks require the inspection of various nodes, panels and splices.

The second Base 4 check and second base check cycle could be complete by a total time of about 33,000FH and 34,000FC. This will be at about 16 years for aircraft that have been through a base check pattern as described.

This will be close to the interval of the large group of 184 ageing tasks that have an initial interval of 36,000FC. The 36,000FC tasks are therefore often combined with a second Base 4 check.

ATRs are often phased out when they reach a total time of about 36,000FC, however. This is because of the large number of fatigue tasks that come due for the first time, and then are due more frequently. These fatigue tasks are detailed inspections that require deep access, and so add to the content of later base checks. The tasks at 36,000FC require that the ATR undergoes a major airframe check.

The extensive nature of these 36,000FC tasks may mean that the aircraft will be operated up to this check, and then scrapped to avoid incurring the cost of such a large check. This would be at a young age.

There is also a group of 24 sampling tasks with an initial interval of 24,000FC. These are likely to come at about the Base 1 or Base 2 check in the second base check cycle. This group can then be split into tasks that have repeat intervals of 6,000FC, 9,000FC and 12,000FC. They therefore have to be performed again every one, two or three base checks.

A borescope of the engines takes place at 3,000FH. It then has a shorter repeat interval of 1,500FH.

The majority of sampling tasks are generally referred to as ageing tasks.

"These tasks would require the most access, since they are major fatigue and structural inspections," explains Gallagher. Typically, the purpose of these grouped tasks is to uncover fatigue damage and so occur at higher intervals, as the airframe ages and undergoes wear and tear from high accumulated FHs and FCs.

The MPD groups these with three main initial thresholds of 18,000FC, 24,000FC and 36,000FC. Repeat intervals are then between 3,000FC, 6,000FC, 9,000FC, 12,000FC or 18,000FC onwards. "For tasks at 36,000FC, the labour exceeds 400MH," outlines Delisle. "This is together with 110MH for access." Tasks that apply to all aircraft in ATR fleet include a detailed inspection of the front and centre nacelle sections for cracks. This initially occurs at 36,000FC, and then takes place every 18,000FC thereafter.

It must be remembered that these tasks are sampling tasks, and so only affect 20% of an operator's fleet. They do not, therefore, necessarily have to be performed for the other 80% of the fleet.

Aircraft that enter and exceed third base check cycles are usually regarded as ageing airframes.

Corrosion appears to be a recurring issue on the ATR 42 and 72 when performing deep access tasks. "Treatment or replacement of corroded parts can take thousands of MH to restore, and they are often among the most difficult parts to source," explains Peters at RAS. The huge costs involved can also make the aircraft a suitable candidate for parting out if it is approaching its third base check cycle. "It is worth noting that there are no maintenance reserves in place to address unscheduled corrosion findings, which suggests high costs for operators when they arise," highlights Peters.

ADs, SBs and modifications

"Overall, ADs and SBs have a low impact on maintenance costs and asset management of the aircraft," says Delisle at Sabena Technics.

There have been some exceptions on the ATR line, however. These are typically noted in each revision of the MPD, in the task reference and source document columns.

"We developed an SB to address a common issue for cargo compartments," explains Peters. "Floor panels were often getting damaged because the panels were becoming delaminated. This was an expensive problem for customers. By covering the composite panels with aluminium plates, we were able to bypass this as a future problem.

An MH factor of 1.0-1.25 is applied when performing SB work, rather than the 2.5 for all other routine MPD tasks.

A significant AD came into effect in 2009 and involved a substantial modification for early models of the ATR. It required the installation of a multi-purpose computer (MPC) with Aircraft Performance Monitoring (APM). This was to assist flightcrew with identifying severe icing conditions as soon as they were encountered, to avoid prolonged exposure and prevent incident. The AD

Access and preparation man-hours have to be factored in when performing the largest and most in-depth routine maintenance inspections on the ATR.

had to be carried out no later than the second base check or within 72 months, and concerned all ATRs, for example 42-500s up to MSN 641. Higher aircraft MSN were fitted with the MPC as standard on the production line. "Retrofitting the MPC took about 350MH," says Peters.

A second major AD emerged in 2014 and concerned main landing gear (MLG) hinge pins. This followed several reports of cracked rear hinge pins on the ATR 72, and the subsequent discovery that this was due to a production error where a non-detected thermal abuse had occurred during manufacture. These hinge pins therefore had to be replaced within a certain batch. The total cost to each operator was about $100,000, and the issue affected almost all except the youngest models. Due to the demand, lead times were also extensive so this delayed the return of the aircraft to service in some cases.

Refurbishment & paint

As covered in previous articles, refurbishment and cosmetic work is at the discretion of the operator. The other scenario is during a lease return, when the ATR is returned to a lessor and/or leased out to a new operator. "A typical regional operator will often combine refurbishment tasks with the 4YE or 8YE tasks. This will include cushion and carpet replacement," estimates Peters. Other cabin adjustments such as the refoiling on interior panels or the replacement of overhead bins is less common, often during either the base check with the large group of 8YE or 12YE structural tasks. "Repainting the exterior is often combined with the 8YE group of inspections, or of course an owner change," continues Peters. "It is not uncommon for a 25-year-old ATR to have had four or five different owners." A typical repaint can cost up to Eur 75,000, including the weight and balance inspection needed after the process.

"It can take up to 850MH to carry out a full strip and repaint on the ATR," according to Delisle at Sabena. "It depends on the complexity of the paint scheme, which will vary between operators."

In Sabena's experience, interior refurbishment can be carried out as often as every two or three years, and be combined with a C check accordingly. "Galleys are strictly limited to a bar including a hot jug and two half-size trolleys. 80% of these parts are refurbished and only seat cushions are replaced. On average it takes less than 150 MH to refurbish the ATR 42/72," continues Delisle.

Rotables & LRUs

The ATR has about 400 line replaceable units (LRUs) and serialised parts. Avionics, hydraulics and generators are monitored on-condition (OC) whereas propellers, engine, and safety equipment are maintained hard-time, with set replacement parameters.

In terms of rotable components, there are about 450 on the ATR42/72. "Most of these are maintained on an on-condition basis, and only a few (12 items) are maintained on a hard time basis," outlines Delisle at Sabena Technics. "The engines can also be monitored on-condition if the operator has an engine monitoring programme (ECM). Other components maintained on a hard-time basis include starter generators, landing gears, oxygen cylinders, fuel nozzles, propeller blades, and the propeller hub.

Parts provision

Alongside typical base checks, repair work and line maintenance, RAS has an extensive parts and spares shop. This is primarily as a result of its additional capacity of buying end-of-life ATRs to part-out and store. "From this business capability we are able to offer customers easily accessible serviceable or repaired OEM parts," explains Peters. "Common examples are hard-to-source airframe, interior or seat parts, which present huge lead times for operators and maintenance providers trying to source them. We have them on site here. Alongside this, RAS is able to locally manufacture parts under their Part-145 approval. This is in the event that parts are not available on the market or lead times are too long when needed by operators."

Summary

The ATR has a relatively simple MPD with a clear set of heavy task patterns, allowing operators to adapt and tailor its demands to its respective operation and requirements. Its MSG-3 based structure is reflective of many mainstream aircraft types over recent decades, meaning the format is well recognised by maintenance providers. Emerging aircraft, and newer types to the ATR, have far more complex MPD formats, which create complex and multi-dimensional platforms that mean even greater adaptability for airlines. This is in line with the increasing demands from the aviation industry. Whether it is the expectation of greater route diversity, more frequent schedules or shorter turnaround times, the benchmark for reliability and efficiency has been raised significantly since the industry was established. AC