Extending maintenance inspection & check intervals is a laborious process that requires the collation & analysis of large volumes of reliability & non-routine data over an extended period. MRO IT systems can collate the data, automatically report and analyse it, simplifying the process.

Systems to extend maintenance intervals

Maintenance organisation has evolved over the past 30-40 years from a system involving packages of tasks with fixed intervals, to one with some maintenance tasks being performed on an on-condition basis, and the remaining ones being assigned intervals so that airlines may package them into checks as they wish. An increasing number of maintenance tasks are being performed on-condition, while the intervals of other tasks have been extended compared to their counterparts in older aircraft.

This evolution has been made possible by the constant assessment of component and system reliability, and the analysis of findings and non-routine occurrences. Monitoring the installation, failure and removal times of components and their mean time between removal (MTBR) allows their reliability to be assessed. As components demonstrate improved reliability, their maintenance intervals can be extended, or their maintenance can be changed to on-condition. The causes of component failure can also be monitored, which allows relevant modifications to be made, and their effect on reliability and MTBR to be followed. Non-routine ratios and findings of scheduled inspections can also be tracked, allowing adjustments to maintenance inspections and their intervals to be made.

This has resulted in more flexible maintenance planning, longer maintenance intervals, and modifications to improve component reliability. In turn these have reduced maintenance and rotable inventory costs.

It is mandatory for airlines to report their component reliability data and non-routine findings at regular intervals to their local authorities. Some or all of the same information is also passed on to the original equipment manufacturer (OEM) of the aircraft, engines and components.

Maintenance intervals are extended in two ways. First, the OEMs can extend the intervals of some inspections in the maintenance planning document (MPD), and then issue a revision to the MPD. This happens regularly. The A320 family's MPD, for example, is at revision 31. Airlines then take these revised MPDs and apply to their local authority to use the new intervals in their approved maintenance programme (AMP).

The second method of escalating maintenance intervals involves airlines applying on an individual basis to their aviation authorities to escalate one or more inspection intervals.

In recent years, the traditional manual paper records used for reporting and evaluating findings and non-routines, tracking and analysing component system reliability, and tracking aircraft utilisation have been replaced by electronic systems that are less time-consuming and provide more accurate and detailed information.

Aircraft in operation

Airlines are legally obliged to record and monitor aircraft utilisation and technical problems through technical logs and pilot reports (PIREPs). The aircraft technical log also follows flight and block times. Engine removal intervals are followed in relation to block time, while maintenance check intervals are related to flight time. More airlines are now using electronic technical logs (ETLs) to feed information directly to their maintenance IT systems. This allows aircraft utilisation and technical problems to be quickly loaded and recorded, more accurately than if using traditional paper records.

Various parameters are recorded while an aircraft is in operation. Besides flight and block times, and fuel consumption, technical logs also record PIREPs. These will list technical problems that arise during operation, involving flight instruments or system components, for example. Line mechanics will investigate these faults or problems when the aircraft arrives on the ground.

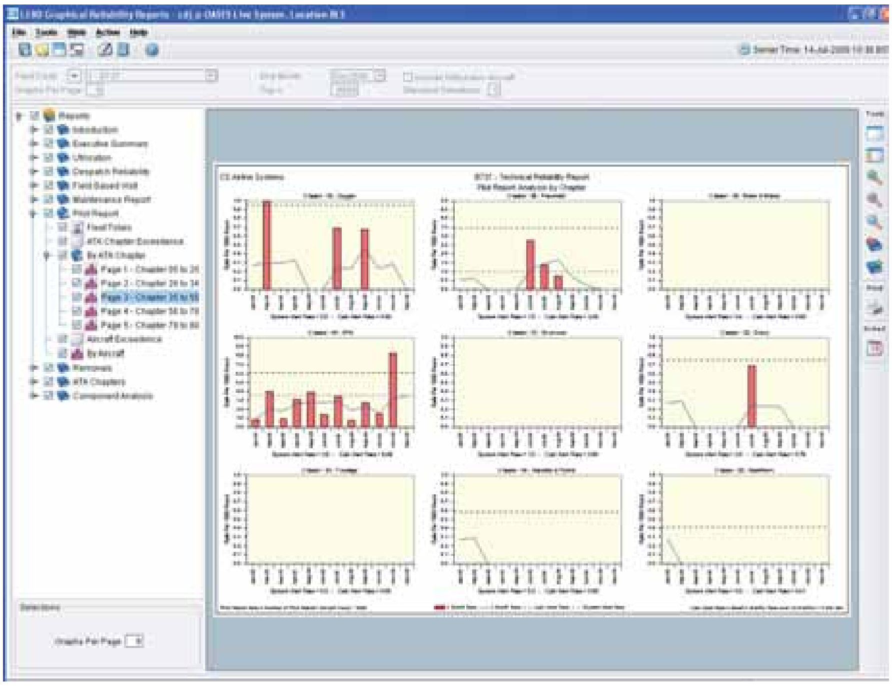
Work orders to fix problems are written by engineers, and then used by line mechanics. Most maintenance, repair and overhaul (MRO) information technology (IT) systems will have an aircraft configuration and component tracking capability. The component that is removed and its replacement are both tracked using their serial numbers.

Tracking components allows their installation and removal times to be recorded. The MTBR and spread of removal intervals for each component number and sub-part number can be tracked. Not only must the MTBRs for all parts be recorded for the airline's own internal purposes, but they must also by law be sent to its local authority. These data are also sent to the aircraft manufacturer, who can use data from all operators of the aircraft type to build a database of MTBR for every part and sub-part number to gain information about their reliability.

The second issue in aircraft operation is findings made during line maintenance, either as a result of scheduled maintenance inspections with fixed intervals, or unscheduled problems. These can relate to physical damage to the aircraft, or problems with a basic component such as a brake unit. The engineer will write a work order to fix the problem, and this will be passed to maintenance planning. These findings are also reported to the manufacturer for their analysis.

The third category of items recorded during aircraft operation is the findings and non-routines that arise during scheduled hangar maintenance as a result of maintenance inspections with fixed intervals. These are either written by mechanics manually, or typed into the maintenance IT system.

These findings are used by mechanics to write non-routine cards, which will often combine findings with relevant pages from the aircraft maintenance manual (AMM), illustrated parts catalogue (IPC) and other documents. These findings also have to be kept in an airline's own maintenance records and reported to its local authority. While not



Commsoft's OASES system has a dedicated component reliability function called LE80. This can analyse component reliability based on removal data and PIREPs, and display the results graphically according to ATA Chapter and sub-chapter.

a legal requirement, they are also useful to the aircraft manufacturer for analysis, because they provide information on system and component reliability, and the level or severity of non-routine findings. Examples are the level of corrosion, or degradation of components or structures.

Recording data

These data have to be recorded by maintenance systems not just for reporting to aviation authorities and the OEMs, but also for airline internal use and analysis.

All maintenance systems have formats for collating and displaying component reliability and non-routine findings data and information.

Information picked up during daily operations has to be analysed. "Our AMOS system distinguishes between PIREPS and maintenance findings, as well as reporting defects that are related to the minimum equipment list (MEL)," says Ronald Schaeuffele, chief executive officer at Swiss Aviation Software. "The system can calculate the number of departures with open MEL items, the number of open MEL items per 1,000FH, and the utilisation of open defect time."

Then there is the recording of defects and findings made during scheduled inspection tasks. "OASES is able to analyse defects and findings recorded by mechanics during maintenance checks," says Nick Godwin, business development director at Commsoft. "The system records basic parameters such as the task card number and how many times the task has been performed. It also records the defects and findings reported over a particular period. These are then compared to previous periods, and the rate of defects and findings per workcard or task number is monitored this way.

"The defects-finding analysis report lists the workcard number, the maintenance reference, frequency of the card, number of defects found, the rate of the past 12 months, and the rate for the 12 months before that," adds Godwin. "An airline will be looking for a drop and steady decline in the rate of findings and defects for particular maintenance inspections, since this is required by the OEMs and authorities to escalate the interval. These data are used together with strip reports. Generally, if the fault rate is low or zero then the task interval is escalated. Rising defect rates are alerted.

"Fault and defect rates can fall if additional maintenance is performed, such as lubrication or a modification being implemented through a service bulletin (SB)," continues Godwin.

Then there is the analysis of component and system reliability. "Tracking components for removal intervals in our AMOS system provides data relating to MTBR, mean time between unscheduled removals (MTBUR), and mean time between failures (MTBF)," explains Schaeuffele. "The system also has alert limits, so that if a component is failing at a rate higher than the limit an alert is given. AMOS also reports on aircraft system and overall aircraft reliability. These reports are made by ATA Chapter, and defects can be listed as rate per 1,000 flight hours (FH), by ATA Chapter or sub-chapter."

The OASES system has a dedicated component reliability analysis function. "OASES compiles an LE80 report. This analyses and displays component reliability data based on removal data, technical log entries and PIREPs," says Godwin. "The information can be displayed according to ATA Chapter, sub-chapter and even at individual component level. It can also pick out recurring faults. We can also programme the system to make alerts about frequently recurring problems. It is used as the basis for filing reports with aviation authorities. Selecting the data takes just a few seconds and compiling the report just a few minutes. These reports are usually about 100 pages and highlight key reliability trends and repetitive defects by ATA Chapter and sub-Chapter. Most operators also use the repetitive defect alerting facility to alert higher than acceptable rates of removal or PIREPs. This is part of a continuous airworthiness review process. Unacceptable rates can be targeted by clicking through to the detail of strip reports and PIREPs to refine maintenance practice."

Feedback loop

These maintenance data have to be compiled and reported as the first stage to extending or escalating fixed maintenance inspection intervals and gaining a picture of component reliability. "By law airlines have to send reliability, removal and MTBR data for every component to their local authority. Airlines report reliability and MTBR data by Air Transport Association (ATA) chapter and sub-chapter number," explains Chris Reed, managing director at TRAX. "This reporting is mandatory because of safety issues, and poor reliability and frequent or severe findings will lead to service bulletins (SBs) and airworthiness directives (ADs) being issued by aviation authorities."

Work orders and non-routine cards are sent to the OEMs, who get data in relation to ATA Chapter and task card number. The OEMs collate and analyse non-routine findings. MRO IT systems are able to list MPD tasks in the order of the highest findings or removal rates. Systems can also be used to provide all the necessary reports for the airline to make an interval escalation request.

OEMs also receive component reliability data so they can issue SBs, which detail modifications. OEMs have to notify aviation authorities of SBs that have been issued so that the authorities can evaluate whether it is necessary to issue an AD.

Reliability data and inspection findings are not the only information reported by airlines. "The core of data collection captured in the maintenance system database during the day-to-day use of the system is aircraft utilisation, aircraft maintenance status, aircraft configuration and component tracking," explains Thanos Kaponeridis, president and chief executive officer at Aerosoft Systems Inc.

There are several ways airlines can file these data and information. "Airlines can schedule to report data to authorities and manufacturers once a month," says Schaeuffele. "There has been a standard format for reporting data since 2004 known as Spec 2000 Chapter 11. Our AMOS system retrieves all the relevant data and information and uploads it to the relevant manufacturer. AMOS provides eight or nine XML files. In the case of Boeing, the data is uploaded to www.myboeingfleet.com, which provides a variety of customer support services for Boeing aircraft, including ordering parts and reporting data. AMOS can send data directly to the OEM or via an FTP site."

Manufacturers have different ways of accepting data from operators. "Bombardier has developed data tables for use by all its customers," says Kaponeridis. "These are filled in by all its customers each month. They include reliability data, aircraft utilisation, defects, SB compliance, and component removals. The standard of these tables is electronic data standard exchange (EDSE). The system is quasi-Spec 2000, and is being upgraded to Spec 2000.

"Boeing has an in-service data program (ISDP), which is its standard for reporting reliability data, and is Spec 2000 compliant," continues Kaponeridis. "All manufacturers have developed systems for electronically collecting these data from airlines. The interfaces that MRO IT systems make with the manufacturers have been standardised so that they all communicate in the same way."

Not all airlines use the Spec 2000 reporting standard, but its standardisation makes it easier for OEMs to interpret and analyse data. "Airbus operators are required to report data in Spec 2000 format," says Godwin. "If an operator does this then it can compare its data with the fleet averages of the same aircraft type. The capability for reporting via Spec 2000 is being developed, but airlines say it is not so critical. Spec 2000 is more related to tracking component reliability than findings reports."

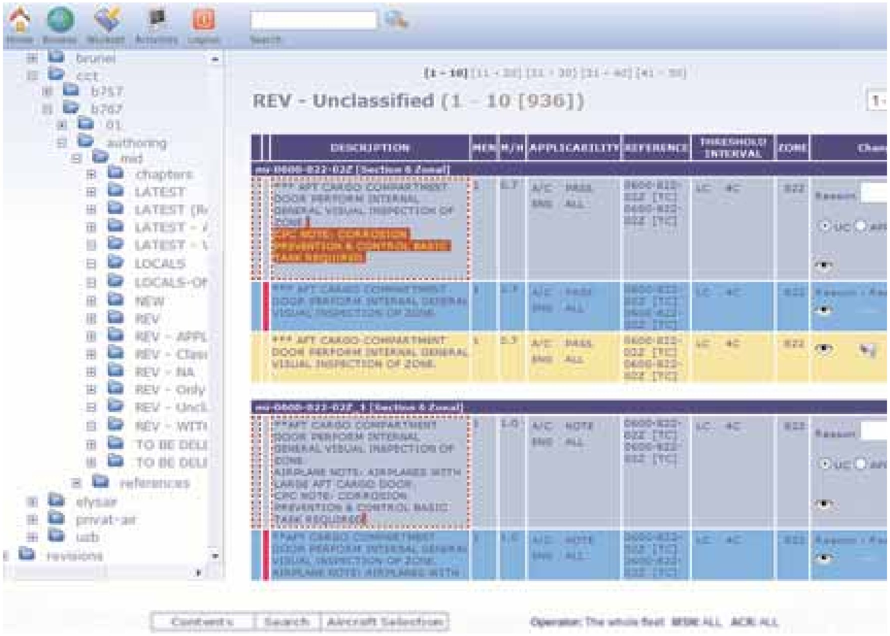
Escalation

The crucial part of maintenance interval escalation and improving component and system reliability is through accurate reporting. This can be done in two ways.

Components that are maintained on a hard-time basis can either have their intervals extended, or they can be changed to on-condition maintenance. This type of change has to be requested. Components already maintained on-condition can have their reliability improved through modifications made via SBs. These modifications are issued once the failures have been comprehensively analysed using data collected from large numbers of the same component.

Component removal intervals are relatively easy to escalate, since operators have always kept comprehensive data on these for their own internal use.

"Task intervals are extended when data illustrate a low ratio of findings and non-routine defects," says Schaeuffele. "Tasks can be de-escalated if findings are high. The alternative is to change the task card so that a lower rate of findings results, or to achieve the same effect by issuing an SB to improve the reliability of the system. In this case the system



Aerosoft's Digimaint and WinPmi systems have the Digidoc content management system that allows old and new maintenance programmes to be compared in a fraction of the time that a planning engineer takes to do the task manually.

concerned might relate to a manufacturer who is not the aircraft or engine OEM. The manufacturer of the components will be consulted about issuing SBs to improve a component or system.

"Aviation authorities and OEMS sometimes require an SB to be issued so that a system's or component's reliability is improved before an interval escalation will be improved," continues Schaeuffele. "AMOS can compare the reliability of modified and unmodified aircraft so that the effect of the modification on improving reliability can be analysed. It can clearly be seen if, following a modification to maintenance practice, the non-routine ratio has improved. If this is the case then the interval can be escalated. An authority may only allow an escalation on some of an operator's fleet, especially if it is a small- or medium-sized fleet which will have a limited amount of reliability data. If the escalation can be shown to be improving reliability data then the operator may get approval to apply the escalation to all of its fleet."

Kaponeridis explains further. "Several categories of maintenance inspections can be escalated, such as mandatory inspections specified in the MPD, or maintenance tasks that have been added by the airline in its own approved maintenance programme. Escalation requests are split into three categories. The first comprises scheduled maintenance tasks. These can be whole checks, individual tasks or passenger service items. OEMs and authorities look at a sample of historical data, and if there is a 95% or more confidence level that the non-routine ratio is at a particular level then an escalation will be approved.

"The second group are structural inspections," continues Kaponeridis. "These are corrosion prevention control programme (CPCP) and structural significant inspection document (SSID) tasks. Findings for these are classed at levels of 1, 2 or 3. If findings can be kept at level 1 then escalations are usually granted. If findings are at level 2 or 3 then escalations are not get approved. The third group of inspections are fatigue-related items, and these are not considered as candidates for escalation."

Implementing escalations

Interval escalations from OEMs are published through revisions of the MPD. "The new MPD is uploaded into the IT system, and several steps are taken," says Schaeuffele. "AMOS compares the last revision with the new one, and lists the MPD inspections whose intervals have changed. The tasks are rescheduled by the system, but some are repackaged manually by planning engineers."

Tasks can be de-escalated, and what happens depends on whether the change is being triggered by the operator or the OEM. "OEMs consolidate data for a total fleet to escalate intervals. Once the MPD revision has been published each airline affected has to see how the tasks whose intervals have changed affect their own maintenance programme," explains Kaponeridis. "Ideally all tasks in a check would be extended. So an operator would like all inspections with a 400FH interval in an A check to be extended to 500FH. Typically, however, only some tasks are extended, so the operator must decide how to reorganise its maintenance programme. Is it worth escalating the interval to 500FH, and have tasks at 400FH drop out as out-of-phase tasks, or should the check interval stay at 400FH until more tasks have been escalated?

"This problem occurs throughout the maintenance programme when a new revision is published," continues Kaponeridis. "This means the airline has to totally reorganise the maintenance packages when a revision is made. Our Digimaint and WinPmi systems have the Digidoc content management system. This allows the impact of old and new maintenance programmes to be compared. The changed task intervals are then implemented. An engineer looks at the tasks that have had their intervals changed and determines what the effect of escalating these intervals is. An engineer analysing an MPD change manually takes about three weeks, while Digidoc can do it in three hours. The system is specialised, so it can drill down to several levels to analyse the effect."

Benefits of escalation

Once interval escalations have been implemented it will be several years before their effect is fully felt. A large number of aircraft that have had the escalation will need to have the inspection performed and the result of non-routine occurrences and findings analysed. "AMOS can make comparisons to illustrate the benefits of escalations. One is to compare the findings and non-routine rates for aircraft over the two years since an escalation has been made, with data for the past five years, in order to detect any significant change in the rate of non-routines," says Schaeuffele.

When check intervals are escalated, a clear benefit is a reduction in the rate of labour man-hours (MH) for routine maintenance per aircraft FH. The issue is, however, what effect escalating intervals will have on non-routine ratios, which can increase due to longer intervals between scheduled inspections, and offset any benefit of check interval escalation.

The aim is to have a zero or small increase in the non-routine ratio so that there is an overall reduction in maintenance labour expenditure per FH. "One example is escalating A check intervals from 500FH to 600FH and C check intervals from 4,000FH to 5,000FH. It has been estimated that this would save $400,000 per year for a fleet of 50 aircraft," says Reed. "The saving depends on how much non-routine will increase due to intervals being extended. In addition, it is always possible that the cost of materials will increase." AC